



Analysis of Cell Biomechanics Response to Gravity:

A Fluids for Biology Study Utilizing NASA Glenn's Zero Gravity Research Facility

by

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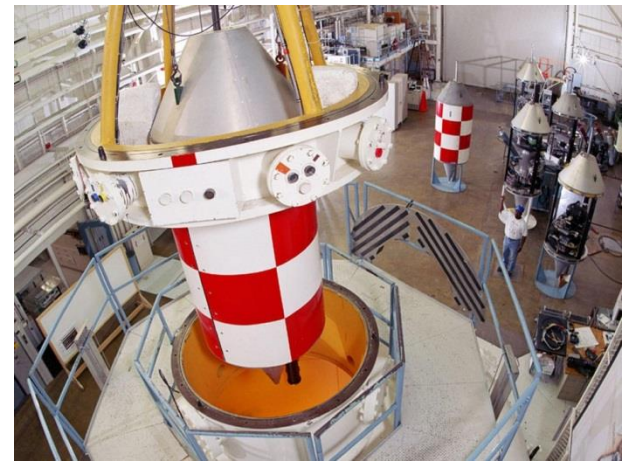
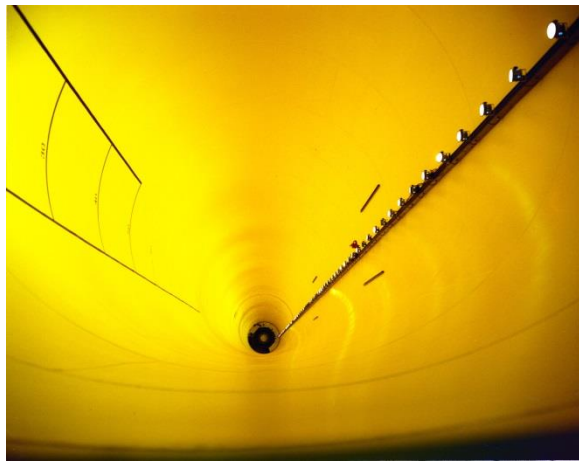
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PROBLEM: It remains unclear how biological cells sense and respond to gravitational forces. Leading scientists state that a large gap exists in the understanding of physiological and molecular adaptation that occurs as biology enters the spaceflight realm. We are seeking a method to fully understand how cells sense microgravity/gravity and what triggers their response.

Utilizing NASA's Zero Gravity Research Facility offers unique capabilities and opportunity to investigate this phenomena.

GOAL/INNOVATION: To study the biomechanical behavior of cells as a step change in gravity, from 1g to 0g utilizing Glenn's Zero Gravity Research Facility. We aim to answer the fundamental science question of how gravity affects the transient (short-term) response of cellular membranes phenomena, a key part of how cells adapt when exposed to long-term microgravity or zero-gravity environments (currently not possible on the International Space Station).





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NASA's Zero Gravity Research Facility

Currently used by NASA funded researchers from around the world to study the effects of microgravity on physical phenomena such as combustion and fluid physics, to develop and demonstrate new technology for future space missions, and to develop and test experiment hardware designed for flight aboard the Space Shuttle or International Space Station.

The Zero-G facility provides researchers with a near weightless or microgravity environment for a duration of 5.18 seconds. Microgravity, which is the condition of relative near weightlessness, can only be achieved on Earth by putting an object in a state of free fall. NASA conducts microgravity experiments on earth using drops towers and aircraft flying parabolic trajectories. Allowing the experiment hardware to free fall in a vacuum, a distance of 432 feet (132 m), creates the microgravity environment at the Zero-G facility.



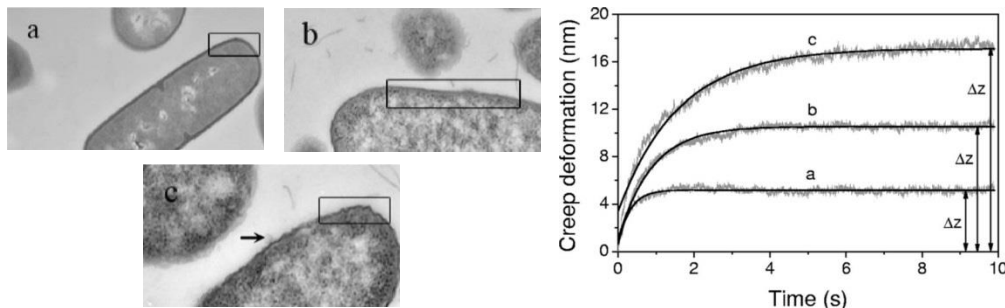
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Data shows that cell response can be observed and measured within the 5-sec experiment time of NASA Glenn's Zero Gravity Facility.

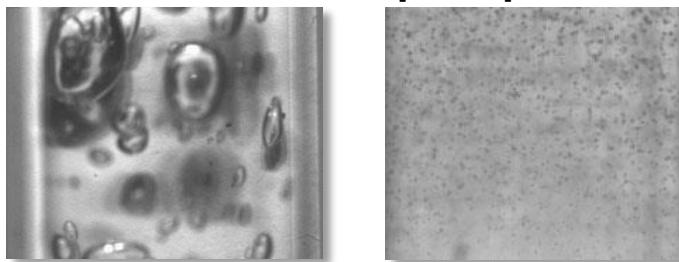
Example showing three different cell responses to an applied force (<5 sec)



Creep deformation as a function of time for *B. subtilis* 168 (a), *E. coli* (lpp-) (b), and *E. coli* (lpp) (c) cells. —Ref. Vadillo-Rodriguez et. al.

In order to gain insight into how cells sense gravity, scientists seek to investigate the transient (short-term) response of biological cells to a sudden exposure to microgravity.

Proof-of-Concept Experiment

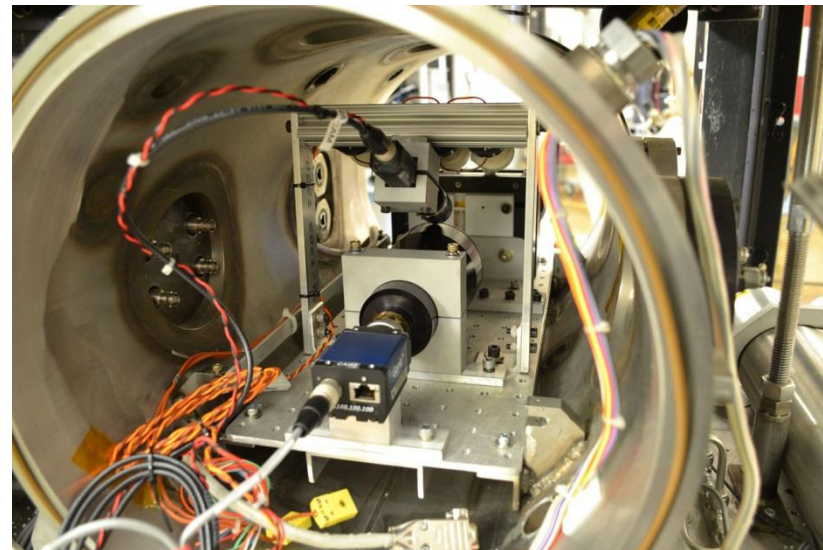
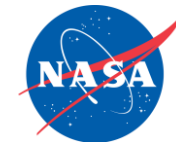


A proof-of-concept experiment utilizing Glenn's 2.2-Second Drop Tower and two simulated experiments combining gel, olive oil, and water have been conducted. These preliminary experiments demonstrate our ability to detect and measure, at similar scale, morphological cellular phenomena that will be applied to Glenn's Zero Gravity Facility experiments.



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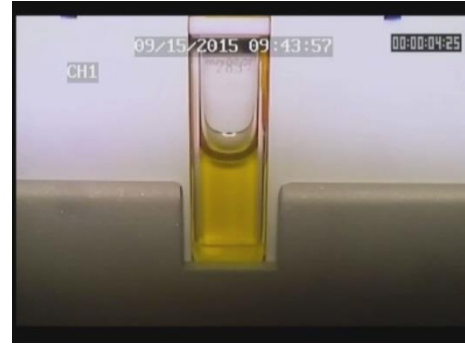
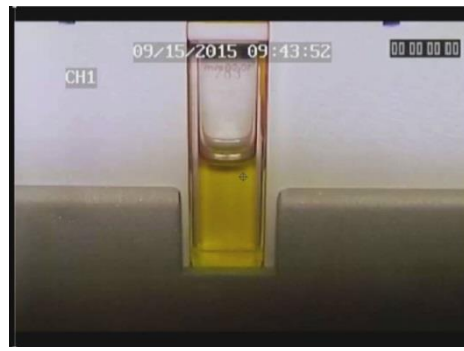
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Zero Gravity Set-up using a two-view camera system



Surface Tension experiment : Initial, During and Impact

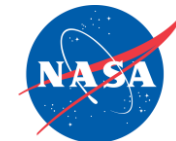


Olive Oil/Water Experiment observing interface morphology



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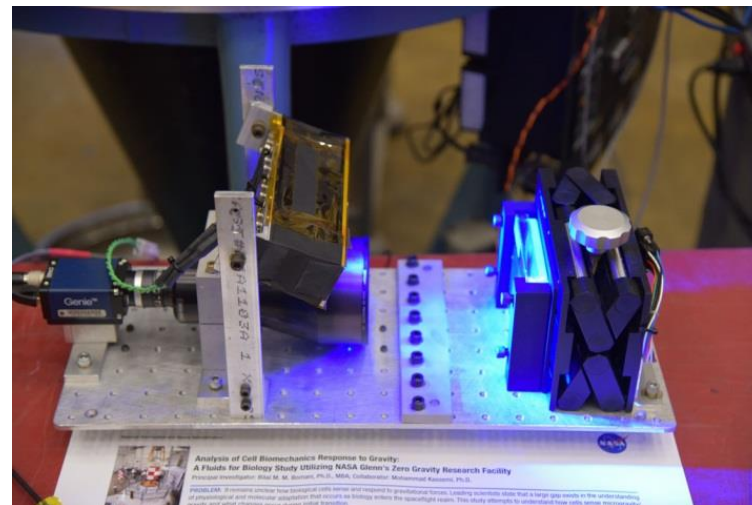
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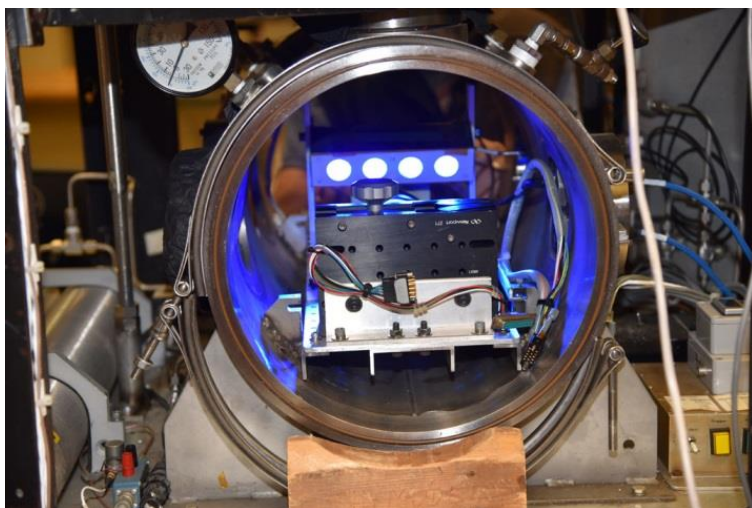
Initial “Real-World” Test Experiment



Plant experiment growth chamber/incubator



Plant experiment just before Drop...



Experiment inside drop tower chamber



Actual experiment results from Plant experiment.



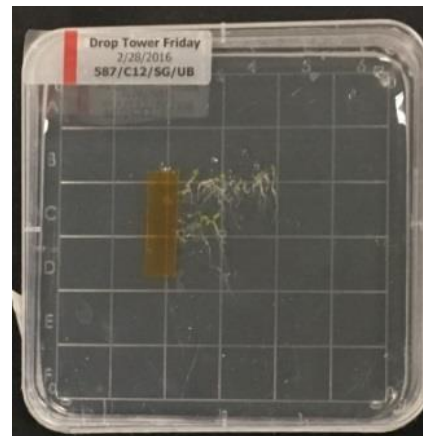
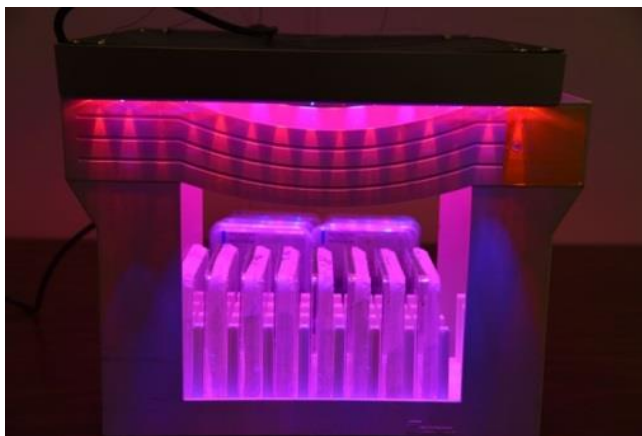
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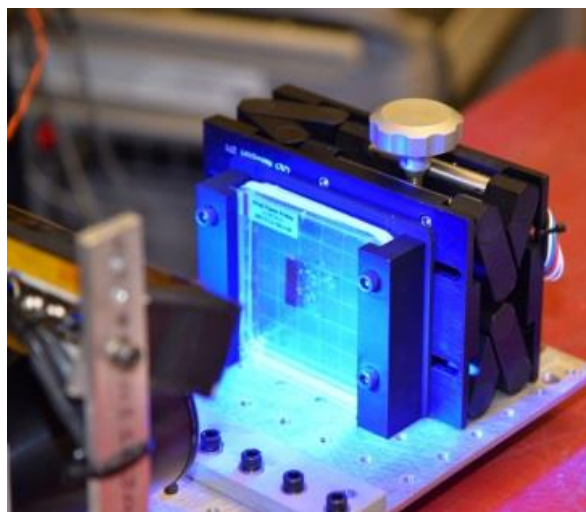
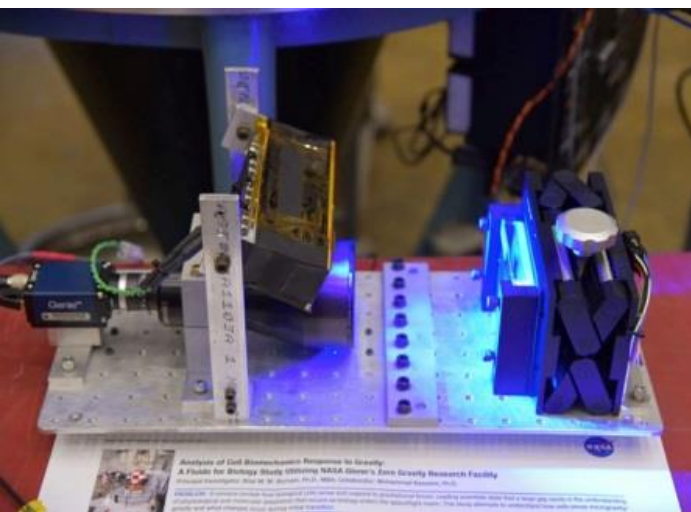


SIF Experiment 1.0 – Analysis of Plant Root Signal Transduction in Altered Gravity

Note: This experiment was conducted and analyzed by Dr. Rob Ferl and Dr. Anna-Lisa Paul of the University of Florida



Petri plates under portable LED growth lights (left) and plate of Arabidopsis plants that comprised the Day 3 drop (right).



Insertion of plate in the fluorescent imager with the excitation LEDs illuminated in pre-drop check.



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SIF Experiment 2.0 – Analysis of Plant Root Signal Transduction in Altered Gravity

Note: This experiment was conducted and analyzed by Dr. Rob Ferl and Dr. Anna-Lisa Paul of the University of Florida

Conducted in August of 2016

The ULTIMATE goal of our research is to conduct a series of low cost systematic drop tower experiments to observe the biomechanical behavior of cell membranes (such as vestibular hair, endothelial, and bone cells) that are known to exhibit sensitivity to gravity.

SUMMARY:

We are developing a useful biology for fluids experiment concept that can potentially be employed by space biology researchers around the world interested in observing, identifying and characterizing changes in biological cell morphology.



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POC:

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